

Rock Lake Stabilization
Soil Bioengineering Research Project - Final
Evaluation, Hwy 60, Rock Lake, Algonquin Park





Ontario
Ministry of
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Rock Lake Stabilization

Soil Bioengineering Research Project - Final Evaluation, Hwy 60, Rock Lake, Algonquin Park

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Date Published: December, 1991

Published by: Research and Development Branch, MTO

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(416) 235-4693

Abstract:: This report details the final monitoring (1988 and 1989) of a soil bioengineering installation on Highway 60 in Algonquin Park. Many of the bioengineering structures have died, although survival was greater on the bottom part of the slope due to greater soil moisture. Despite the mortality, the slope has been stabilized due to the physical structure. One part of the slope was seeded with creeping red fescue and bird's-foot trefoil to prevent surface erosion. As with the woody plant material, growth and survival was greater on the lower part of the slope.

An experiment was planted in 1988, comparing four species of brush layers, branch age (willow only) and the effect of fertilization. All species established better than aspen, which did not root at all. Balsam poplar generally performed better than either willow or dogwood. As with the previous plantings, survival was greatest on the lower part of the slope. Fertilization increased survival in the second growing season, probably due to increased plant vigour over winter.

Adequate soil moisture appears to be the most critical factor for survival of the soil bioengineering structures that were tested. Young, vigorous stem cuttings should be taken from species that root easily. Cultural treatments such as fertilization may result in more vigorous growth once the plants have established.

Comments: Phase 1 and Phase 2 of this project are available as MAT-88-09, MAT-88-10, respectively.

Key Words: *Populus tremuloides*, *Populus balsamifera*, *Salix* spp., *Cornus sericea*, bioengineering, roadside landscaping, propagation, fertilization.

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Published by
The Research and Development Branch
Ontario Ministry of Transportation

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December 1991

92-01869/

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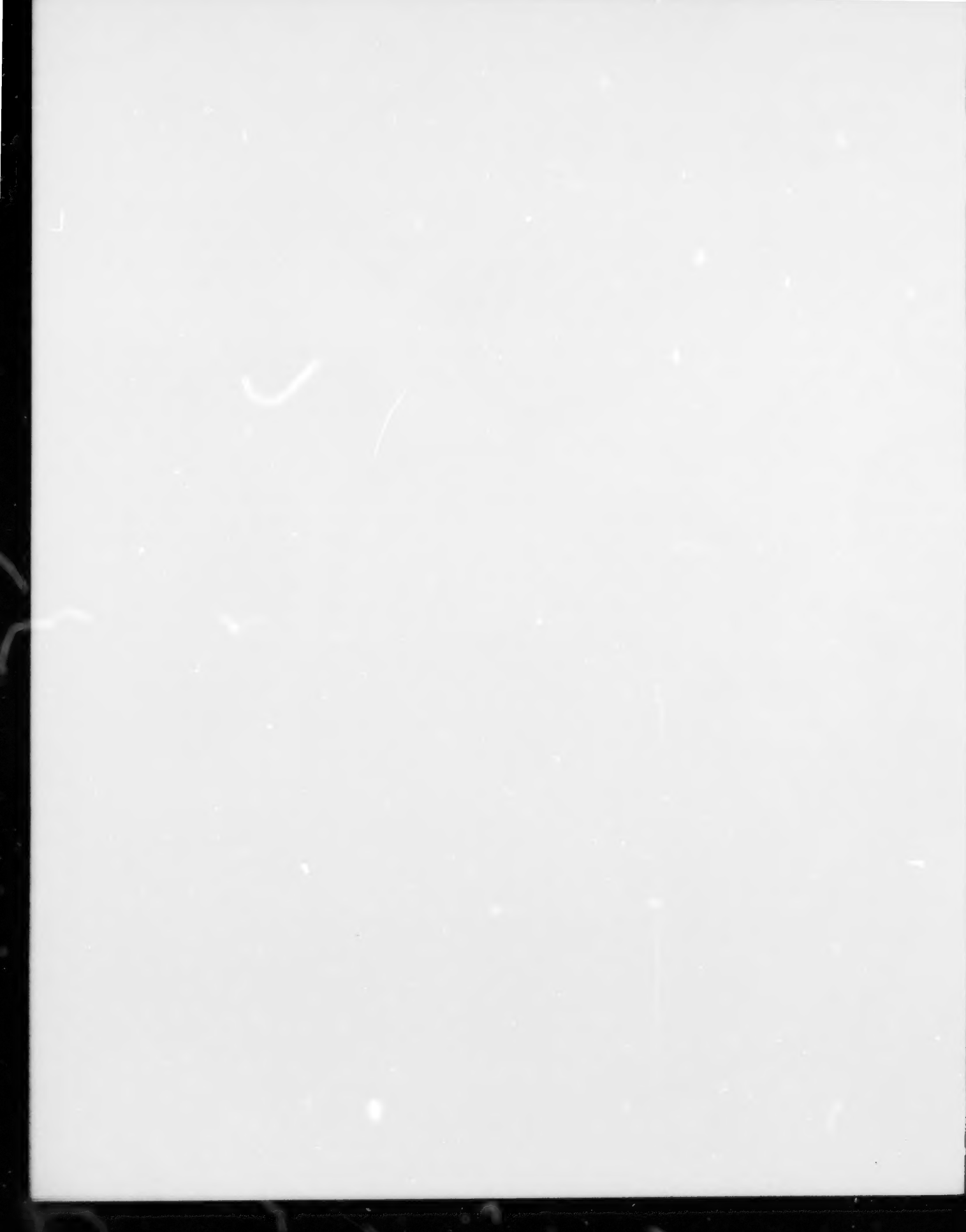
INTRODUCTION

In 1985, Harrington and Hoyle Ltd. was contracted by the Ontario Ministry of Transportation Research and Development Branch to evaluate soil bioengineering as a natural alternative to standard construction techniques used for stablization of steep slopes along provincial highways. A test site was selected on Highway 60 in Algonquin Park and an installation was made in the spring of 1986 following evaluations of the site during the 1985 growing season.

Two earlier reports, MAT-88-09 "Rock Lake Stablization, Soil Bioengineering Research Project - Phase 1" and MAT-88-10 "Rock Lake Stablization, Soil Bioengineering Research Project - Phase 2" described the components of the bioengineering structures, detailed the installation on the Highway 60 site and reported on the survival of the plant material and erosion control provided by the installation.

There were problems with rooting and establishment of the plant material in the original structure. For that reason a surface seeding was done in 1988 and an experiment was initiated at that time to evaluate the effect of species and fertilization on establishment of brush layers.

This report summarizes the final evaulations of the bioengineering project. The report is divided into three sections: 1) monitoring in 1988 and 1989 of the original installation, 2) description of the performance of surface seeding that was done on the site in 1988 and 3) results of the brush layer experiment that was planted in 1988.



Introduction

In conjunction with the trials described under Parts Two and Three, the stability of the site, the growth of the soil bioengineering structures and the invasion of the site by colonizing plants was monitored.

Methods

A general, visual inspection of the site took place in early July, August, and September. During the July inspection, soil and water samples were taken from the site and tested for soil fertility, pH, organic matter and salts, pesticide residues and water quality. A few live stakes and brush layers were excavated at random to inspect root growth and the balance between root and top growth.

Results

In a general, visual inspection, very little change was noted from the previous year on the entire site. The site continues to develop an increasing diversity of healthy plants and lush green appearance on the lower third of the slope and remains predominantly barren on the upper third of the slope. The growth of the plants in the various soil bioengineering structures was very minor this year. Live stakes which grew 200-300mm shoots in 1986 have grown little more than 50mm in 1987 and 1988. This lack of vigour in top growth is matched by a lack of vigorous root growth, where roots tend to be long with little side branching. Similar growth was noted in the high bush cranberry and dogwood rooted material which was installed on site in 1986. Insect damage continues at about the same rate as the previous two years and continues to affect some plants considerably more than others.

Colonization of the lower slope consists predominantly of herbs and grasses with little indication of woody vegetation moving onto the site anywhere on the slope.

The rill erosion noted on the soil surface in previous years became marginally worse in some locations, but still poses no serious threat to the integrity of the slope and does not as yet deposit any material into the ditch.

Generally, the slope remains stable with no indication of slumping or soil creep and only minor surface erosion. The fascine drains continue to work well to dewater the wetter parts of the slope.

Close inspection of the dead soil bioengineering structures showed no increase in plant colonization near or within the shelter of the branches.

None of the soil or water tests performed gave any indication as to the original cause of plant mortality on the site. (See Appendix 1, 2, and 3.)

PART ONE

GENERAL MONITORING

Summary and Conclusions

- The soil bioengineering continues to stabilize the slope mechanically, through the structures installed in 1986.
- The unusually high death rate of soil bioengineering structures has stopped.
- Growth rates on the site are generally poor, for both shoot and root growth development.
- Plants on the lower part of the slope appear healthier and are more numerous than on the top of the slope, but do not show appreciably more growth.
- The difference in appearance and growth rate of the surviving soil bioengineering plants (cuttings) and the rooted material is becoming less distinguishable.
- Colonization of the site occurs mainly in the lower 1/3 of the slope and is generally limited to herbs and grasses.

PART TWO

SURFACE SEEDING

Introduction

During the on-going monitoring of the process of site stabilization following the 1986 soil bioengineering research project, a number of small areas of surface erosion were noted. These occurred on the exposed soil between structures (most notably vertical brush layers) which had failed to grow. It was decided to select one area exhibiting such erosion and seed with grass and legumes to attempt to stabilize the surface. The treated site would then be compared with an untreated area. The purpose was to determine if surface seeding was effective in repairing a soil bioengineering structure which had not grown but which was still functioning well mechanically.

Method

The seed mixture and mulch were selected to simulate a typical Ministry hydroseeding for this area. Bird's-foot trefoil "coated" seed was applied at a rate of 25 kg/hectare with creeping red fescue at a rate of 50 kg/hectare. (Seed was supplied by Oseco Inc.) Fertilizer was applied at a rate of 350 kg/hectare with 8-32-16 fertilizer and mulched using a prepared hydroseed mulch provided by Fibrmulch. The mixture was moistened in place by hand watering.

All applications were by hand and thus some variation in application rates is to be expected.

An area of approximately 75m² was treated, along both sides of a vertical brush layer which had failed to grow. A similar area, adjacent and to the west, was left as a control. The installation was started and completed on April 20, 1988.

Results

The germination and growth of the red fescue grass seed was excellent throughout the application area, creating a complete cover in most areas. Germination and growth of the bird's-foot trefoil was disappointing, for unknown reasons. Plants such as previously established weedy forbes typically grew 50% larger than their neighbours in the untreated areas. Typical of the site, all plants grew better on the lower, moister parts of the slope than on the upper areas.

By the end of the season, no signs of surface erosion were evident on the treated plot.

PART TWO

SURFACE SEEDING

Conclusions

The surface treatment of fertilizer, mulch and seed was very effective in remedying the moderate surface erosion which had been previously noted on the slope. Further observation will be made to ascertain whether or not the combination of the failed vertical brush layer and the surface seeding will facilitate the longer term stabilization and naturalization of the slope. This will confirm the effectiveness of the technique as a remedy for spot failures in soil bioengineering applications.

PART THREE

SURVIVAL AND GROWTH EVALUATION

Introduction

Slope stabilization using soil bioengineering principles has been practiced successfully in many locations. Brush layers, live fascines and live stakes are three components of soil bioengineering. Structure design and the ability of the species to root quickly once in place are important aspects of the technique.

Earlier studies of slope stabilization using brush layers, fascines and live stakes at the Rock Lake site were disappointing because of very limited survival. Considerably more material was alive at the end of the first growing season than survived the winter and grew in the second season.

The purpose of this study was to carefully install brush layers and live stakes adjacent to the previous site in an attempt to evaluate the survival, growth and establishment of several tree and shrub species.

Methods

The study site is a north facing slope adjacent to Highway 60 near Rock Lake in Algonquin Provincial Park. This slope is gravelly sand with numerous stones and contains areas of erosion and slumping. Vegetation on the slope consisted of scattered forbes and volunteer tree seedlings, as well as some previously planted Viburnum trilobum. Moisture conditions varied on the slope. In the spring, the upper slope was slightly moist while the lower one quarter of the slope had numerous wet and soggy areas. Soil tests revealed low levels of phosphorus and potassium, moderately low levels of magnesium and a soil pH of 5.6. (Data not shown, see 1986 and 1987 Reports.)

The slope was divided into three horizontal sections or levels. Level 1 was on the lower slope in the area of greatest moisture, Level 2 was at mid slope and Level 3 was near the top of the slope (Fig. 1). On April 18, 1988, one horizontal trench was dug at each level. Trenches were dug so that the surface sloped into the hill at an approximate angle of 20° from the horizontal. Soil moisture in the trenches froze overnight. Prior to inserting branches in the trenches on April 19 and 20, the thin frozen crust of soil was broken up with a pick.

Four plant species (five plant types) were selected for the brush layers. They were trembling aspen (Populus tremuloides), red osier dogwood (Cornus sericea), balsam-poplar (Populus balsamifera) and willow (Salix spp.). Willow included more than one species; predominantly pussy-willow (Salix discolor) with some material being Missouri willow (Salix eriocephala) and shining willow (Salix lucida). Two types of willow were used. Branches from slower

PART THREE

SURVIVAL AND GROWTH EVALUATION

Methods (continued)

growing plants were termed old willow, while branches from more vigorous plants (2 to 3 years old) were termed new willow. The two types of willow were selected from different plants. All plant material was harvested from sites used for the original installation in Whitney, approximately 20 km east of the site. Plants were cut at ground level with a chain saw, bundled and transported to the Rock Lake site where the material was stored in water overnight. Material for brush layers consisted of branches cut into 50 cm lengths (Fig. 2). Branches were placed butt end in the trench and crossed slightly. Soil was returned to the trench, being careful to pack the soil tightly around the branches (Fig. 3). Branch ends were cut to leave about 20 cm protruding from the soil.

Each level of brush layer consisted of a split plot design with five replicates. The main plot was fertilized at 0 or 150 kg nitrogen per hectare using 10-2-4. A minimum distance of 25 cm was maintained between main plots. Sub-plots were the 5 plant types (Appendix 4).

Live stakes were prepared from straight poplar and old willow branches. Poplar stakes were 4.0 to 5.0 cm diameter and 50 cm long. Willow stakes were also 50 cm long and of two types; large, 4.0 to 5.5 cm diameter and small, 2.0 to 3.0 cm diameter. All stakes were tamped into the ground, using a dead blow hammer, to within 10 cm of the top. Stakes were arranged in a randomized block design with 9 or 11 replicates and placed adjacent to the three levels of brush layers (Appendix 4). The study was observed and rated on August 5 and September 1, 1988, and on September 24, 1989.

Results, 1988

There was very little difference in observations or ratings between August and September, therefore the September data were used for analysis. When observed from the highway, Level 1 brush layers appeared to be more vigorous and have more shoots than those at Levels 2 and 3. Some poplar brush layers had shoots 75 cm long; dogwood and willow shoots were up to 25 cm long (Figure 4). Increasing growth of existing shoots was probably the result of the moist soil conditions at Level 1. Also, the weedy forbes were more vigorous at Level 1.

The application of fertilizer had no effect on regeneration of any of the five plant types (data not shown). Fertilizer added at planting should have no benefit on rooting of hardwood material. However, once material had rooted fertilizer may have been beneficial.

PART THREE

SURVIVAL AND GROWTH EVALUATION

Results, 1988 (continued)

Brush layer ratings indicated that all the aspen died (data not shown). This result was not surprising since aspen is difficult to root from hardwood material.

Poplar layers regenerated successfully at all three levels with a significantly higher rating (greater percentage of shoots alive) at Level 1 (Fig. 5). The moist soil conditions at Level 1 may have been a factor.

Regeneration of dogwood was good at Levels 1 and 3 and greater than at Level 2 (Fig. 5). Dogwood is an easily rooted species. Less regeneration at Level 2 is unexplained.

The old willow (willow 1), which consisted of more slow growing branches, regenerated better at Level 1 than at Level 3 (Fig. 5). At Level 3 survival was very poor. Older branches root less readily and may have responded to increased moisture on the lower slope. Regeneration of young willow was similar at all levels. The young willow regenerated much better at Level 3 than the old willow. Perhaps the young willow was able to root more quickly and thus survive better in the dry soil of Level 3.

Brush layer data from the first growing season indicate that level was a significant factor. More moist conditions lower on the slope likely resulted in better regeneration and establishment.

Poplar live stakes grew most at Level 1 and least at Level 3 (Fig. 6). Small and large willow stakes grew equally well at all levels, although there appeared to be a trend to better growth at Level 1 (Fig. 6). Since Level 1 was the most moist, it is likely that success of live stakes was a response to soil moisture (Fig. 7). Data revealed no stakes with good growth (rating of 4) at Levels 2 or 3, while at level 1, 27%, 22% and 9% of the poplar, small willow and large willow respectively had good growth (data not shown). Small willow stakes had a higher rating at Levels 2 and 3 than either large willow or poplar (Fig. 6). This result may be due to the smaller size, younger age and greater ease in rooting of the smaller willow stakes. Based on sampling only 9 stakes the average age of the small willow was 6 years while for the large willow and poplar it was 10 to 8 years respectively.

Some stakes produced one or more shoots that died before September. Excavations revealed that such stakes had no roots (Fig. 8). Stored carbohydrate and water reserves may enable small shoots to remain alive for part of the season, but root regeneration is critical to survival of live stakes. Stakes that had the most vigorous shoot growth had some root development (Fig. 8).

PART THREE

SURVIVAL AND GROWTH EVALUATION

Discussion

The Rock Lake site has many conditions which would tend to limit the successful colonization of the slope by vegetation. These include steep slopes, lack of topsoil, low soil pH, low soil fertility, variable soil textures, variable soil moisture across the slope and seasonally, limited sunlight exposure, surface solification and exposure to traffic along Highway #60. In addition, the site's location within the provincial park limited the species selection to native material grown within the same region. Initially this was seen to be a good test of the systems and no additional mulching or soil amendments were used to aid the soil bioengineered plants. In addition to these, some problems in construction quality control resulted in incomplete compaction around some of the structures, as noted in the initial reports. This was exacerbated by prolonged droughts in the first and second growing seasons. The relative success of the 1988 brush layer and live stake installation prove the importance of excellent quality control in soil bioengineering installations.

With the exception of the vertical brush layers, all of the soil bioengineering applications grew well at some location on the slope. These include live stakes, brush layers, fascines, and combinations. Wherever the structures were installed, however, they continue to perform their mechanical function of stabilizing the soil erosion on the slope very well.

The research and observations done to date confirm that stimulating the cuttings to root is critical for a successful soil bioengineering application. Four factors emerge as being important in maximizing rooting.

1. Construction Quality Control

The importance of using "fresh" material and ensuring that, upon installation, the cuttings are in complete contact with well compacted soil, free of air spaces. Soil texture and stone content variation can make this very difficult and should be reviewed carefully in the planning of applications. Tight supervision and site testing is recommended for all applications.

2. Species Selection

With the initial mix of willow, dogwood and aspen, the aspen did not root successfully anywhere on the site. Balsam poplar in the second installation, however, grew more than the willow or the dogwood cuttings. As more installations are monitored in Ontario, we will develop better knowledge concerning the performance of various species in various conditions. Other material proven to have rooting potential include cedar, lilac, honeysuckle, viburnum and sumac. These may or may not be useful in some situations.

PART THREE

SURVIVAL AND GROWTH EVALUATION

Discussion (continued)

3. Material Age

The results of the second installation indicate a higher rate of growth and success in the young willow cuttings as opposed to the older wood. Where older material must be used, it is therefore important to mix it with younger material to ensure the best results.

4. Cultivar Selection

Nurseries routinely select cultivars of plants which exhibit superior rooting ability to maximize their propagation success. In a paper presented to the XXI Conference of the International Erosion Control Association, 1990¹, Mr. J. Dickenson suggested that nursery stock selected and grown for superior rooting characteristics is a cost effective alternative for controlling the quality of soil bioengineering material and maximizing the rooting potential through age and cultivar control. At present, there are no such nurseries in Canada and only a few in the United States; however, it is well worth investigating for sites which do not have the native material concerns of the Rock Lake site.

The lack of a single cause for the death of those plants which did root in the first year, tends to point to a cumulative cause of all of the stresses discussed earlier. Plants on the lower third of the slope which had more moisture during the dry summer months, for example, had a much better survival and growth rate. Similarly, the rooted cuttings of high bush cranberry which had fertile topsoil on their roots survived and grew well for a few years, even on the upper parts of the slope. The removal of stresses on the plant material wherever possible by fertilizing, liming, or mulching would, we expect, substantially increase the survival of the material. The second installation shows enhanced growth in the second year due to fertilizer. Non-research applications should attempt to mitigate all adverse conditions, where practical.

¹ Obtaining Plant Materials for Biotechnical Work, by John A. Dickerson, Theodore L. Kelsey, Christopher R. Jones, Donald W. Lake Jr., Raymond G. Godfrey, Proceedings of Conference XXI, International Erosion Control Association, February 14-17, 1990, Washington, D.C., U.S.A.

PART THREE

SURVIVAL AND GROWTH EVALUATION

Discussion (continued)

And finally, the need for ongoing management of sites is obviously important. Fertilizer applications have increased growth in the second growing season. On sites with little organic matter, refertilizing to replace soluble nutrients every two to three years is probably important until a leaf litter zone begins to form and cycle nutrients. Small repairs, mulching, seeding, or planting seedlings for genetic diversity could also be part of an ongoing maintenance program. In this way, the plants can be maintained in a healthy, vigorous, growing condition until they are self sustaining.

Results, 1989

In September 1989 survival of brush layers at Level 1 was significantly greater than at Levels 2 and 3 for poplar, red osier dogwood and young willow but not for old willow (Fig. 9). Most of the layers at Levels 2 and 3 were dead or growing very poorly, with survival less than 10%. Branches of living layers were not heavily rooted (Fig. 10) indicating that surviving layers were not very vigorous.

Survival of layers is dependent on adequate root regeneration and establishment in the early part of the installation year as well as the ability of the root system to withstand the first winter. Without sufficient roots to support shoot growth the branches of the layer would have inadequate carbohydrate reserves to insure winter survival and growth in the following season.

Level 1 was more moist than Levels 2 and 3. Greater survival of brush layers at Level 1 was most likely due to the soil moisture, since adequate moisture is important to sustain root development and shoot growth. The lack of moisture at Levels 2 and 3 apparently resulted in very poor survival.

At Level 1 the addition of fertilizer in the spring of 1988 (during installation) resulted in significantly greater survival in 1989 for poplar and red osier dogwood layers but not for old or young willow. Fertilizer had no beneficial effect on survival at Levels 2 or 3. Perhaps fertilizer enabled greater root and shoot growth thus increasing survival of branches rooted in 1988.

Evaluation of live stakes in September 1989 revealed that survival of all species combined was significantly greater at Level 1 than at Level 3. For both small and large willow there was a trend for greater survival at Level 1 although the difference was not significant (Table 1). Poplar survival was significantly greater at Level 2 than at Level 3. Stake survival was considerably less in 1989 than in 1988 (Table 1).

PART THREE

SURVIVAL AND GROWTH EVALUATION

Results, 1989 (continued)

Excavations revealed that living small willow stakes were extensively rooted (Fig. 11). Small willow stakes survived better than large ones in both 1988 and 1989 apparently because of better rooting of younger branches. Small willow stakes were about 3 years younger than old willow. Poplar stakes were sparsely rooted, without large apparent differences in rooting between living and dead stakes (Fig. 12). Many stakes that were alive had dead areas of bark where no roots or shoots had formed (Fig. 12).

Adequate rooting is very important particularly for overwinter survival. In nursery practice, younger wood roots better.

Summary and Recommendations

Soil moisture was greatest at the bottom of the slope.

Brush layers, in general, grew and survived best at the bottom of the slope.

Aspen brush layers did not grow at any level.

Fertilizer applied to brush layers at planting had no effect on growth in the first year, but resulted in greater survival of poplar and red osier dogwood in the second year.

Live stakes grew and survived equally well at all levels on the slope in both years except for poplar that was better at the bottom or middle of the slope than at the top.

Survival of live stakes decreased considerably between the first and second years.

Small willow live stakes appeared to root more extensively than either large willow or poplar.

Based on evaluations and excavations over two years, adequate soil moisture appears to be the most critical factor for the growth and survival of both brush layers and live stakes. Optimum conditions are important for adequate rooting, helping to ensure survival during the first year. Plant material for both brush layers and live stakes should be as young and vigorous as practically possible. Only plant material that roots quickly should be used. Cultural practices such as fertilization that would stimulate growth should be considered.

Table 1. Survival (%) of three species of live stakes over two years at three levels on a slope.

Level	Poplar		Small Willow		Large willow	
	1988	1989	1988	1989	1988	1989
1	73	22ab	67	37	55	22
2	64	37a	78	12	36	0
3	55	0b	56	12	20	0

Levels 1, 2 and 3 are at the bottom, middle and top of the slope respectively. Data are an average of 9 to 11 replicates. For poplar 1989, values followed by different letters are significantly different ($P=.05$, LSD). All other values in columns are similar.

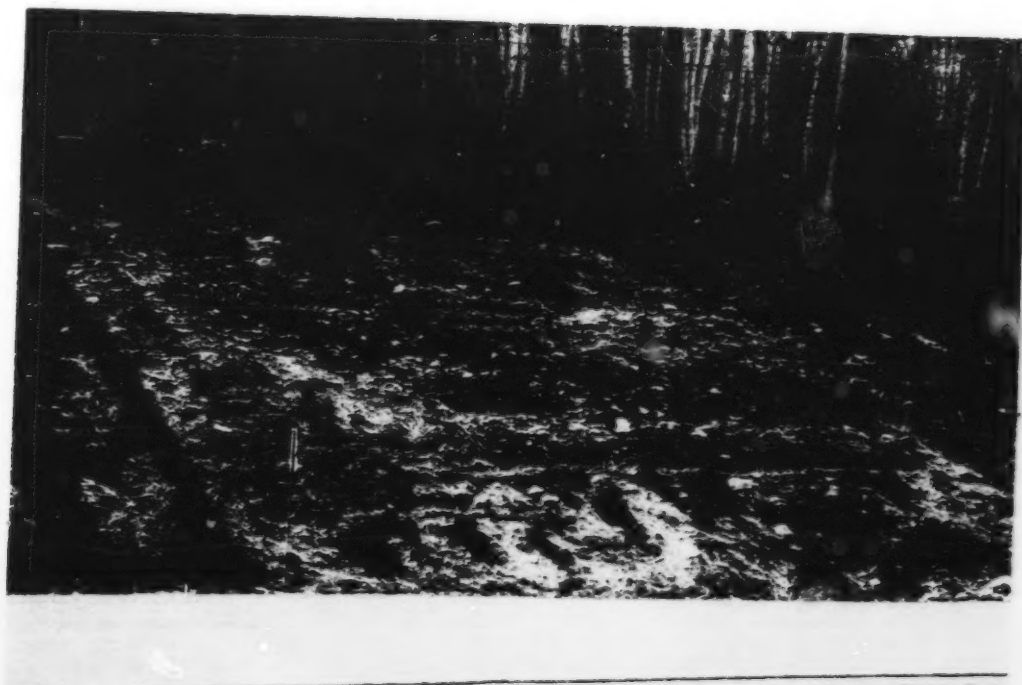


Figure 1/ Soil bioengineering study site near Rock Lake,
Algonquin Provincial Park. The slope exposure is
north. Photographed April 20.



Figure 2/ Bundles of red osier dogwood branches (foreground)
cut to length for brush layers.



Figure 3/ An installed brush layer. Stakes mark plot boundaries. Photographed April 20.



Figure 4/ An example of excellent growth from a dogwood
(left) and a poplar (right) brush layer.
Photographed August 5.

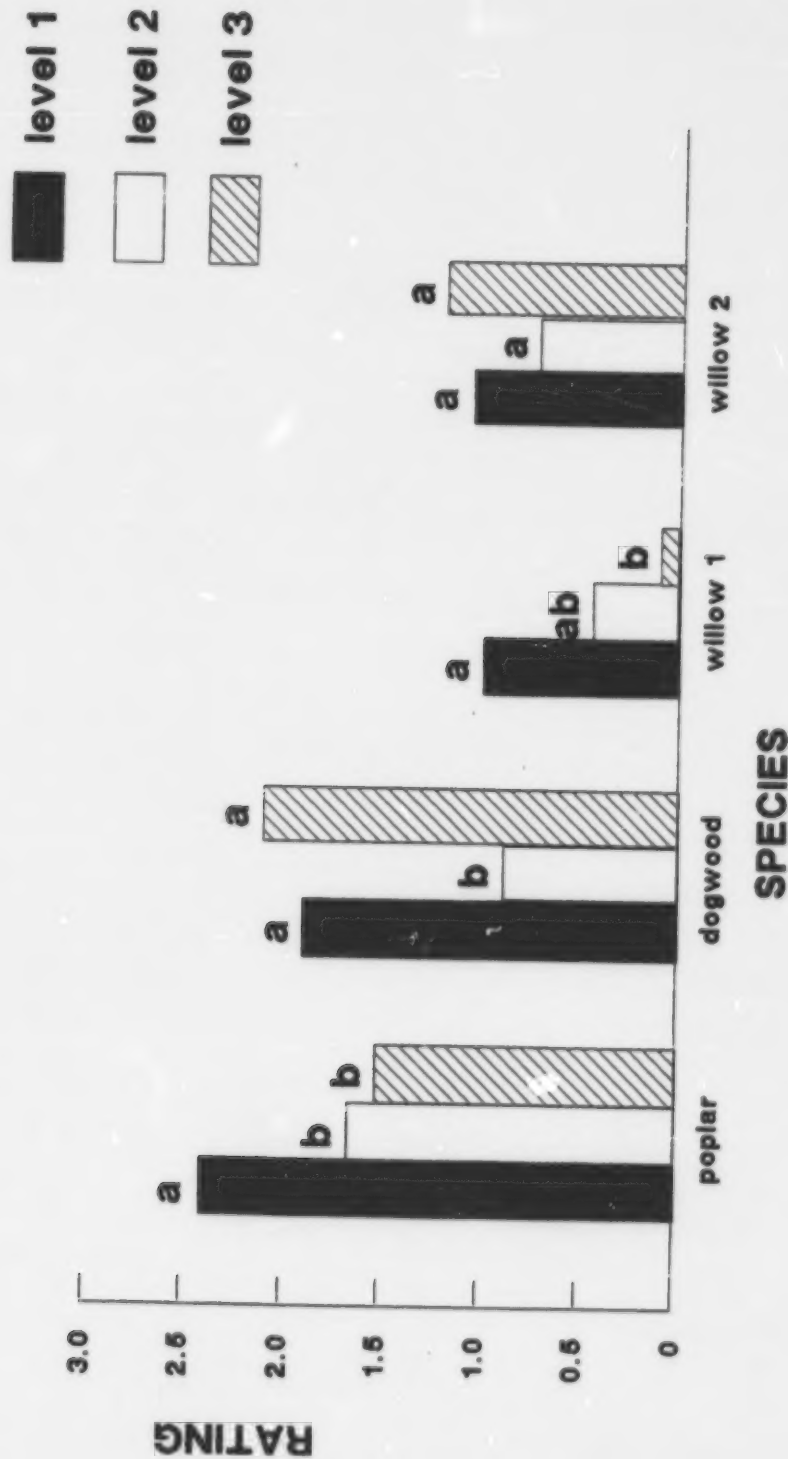


Fig. 5. Brush layer growth ratings, Sept. 1988. Levels 1, 2 & 3 were at the bottom, middle and top of the slope respectively. Ratings were: 0 = dead, no growth; 1 = poor growth (less than 20% of layer alive); 2 = moderate growth (20% to 50% of layer alive); 3 = good growth (50% to 80% of layer alive). Rating data are an average of 10 species replicates per level. Willow 1 and 2 were branches from slow growing and vigorous plants respectively. Within a species bars with similar letters are not significantly different ($P=0.05$, LSD).

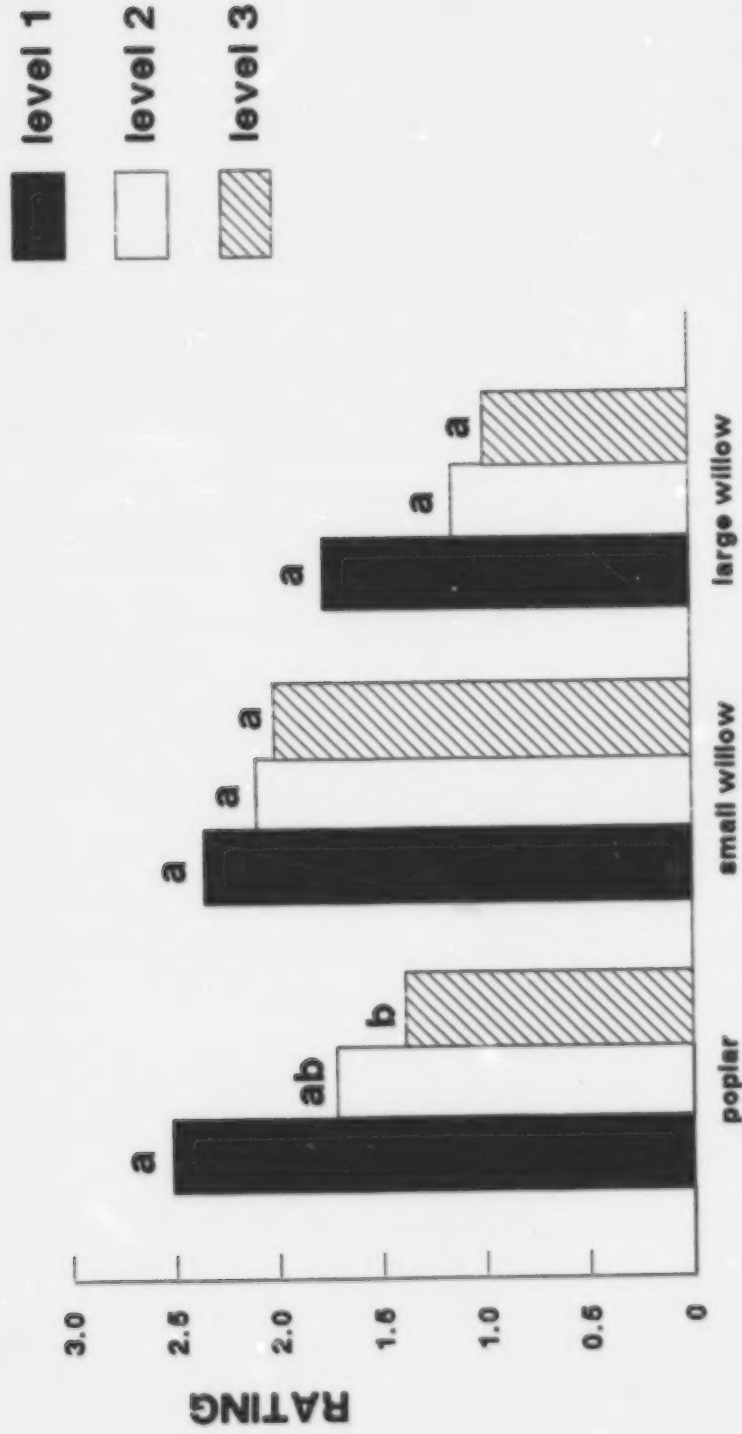


Fig. 6. Live stake growth ratings, Sept. 1988. Levels 1, 2 & 3 are at the bottom, middle and top of the slope respectively. Ratings are 0 = dead, no shoot growth; 1 = dead, previous shoots died; 2 = poor growth (1 to 3 shoots, less than 15 cm long; 3 = moderate growth (3 to 6 shoots, 2 of which are 15 cm or longer); 4 = good growth (more than 6 shoots, 5 of which are 30 cm or longer). Rating data are an average of 9 to 11 species replicates per level. Within a species bars with similar letters are not significantly different ($P=0.05$, LSD).



Figure 7/ A small willow stake showing moderate growth (rating 4).
Photographed August 5.



Figure 8/ Excavated small willow stakes illustrating dead shoots (rating 2) at left and moderate growth (rating 4) at right. Photographed September 1.

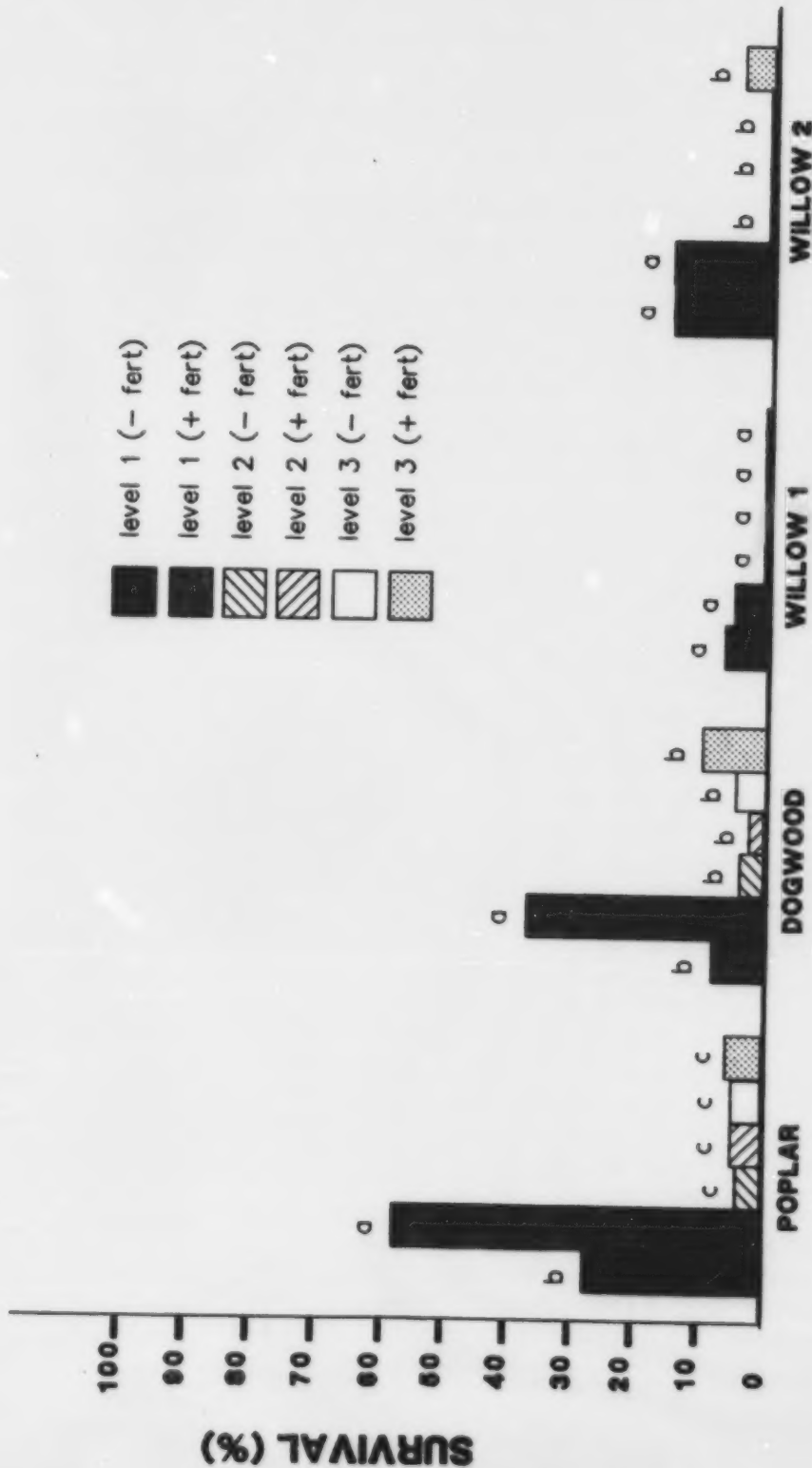


Fig. 9. Brush layer survival, Sept. 1989. Levels 1, 2 and 3 were at the bottom, middle and top of the slope respectively. The + fert treatment received 10-2-4 in the spring of 1988. Willow 1 and 2 were branches from slow growing (old) and vigorous (young) plants respectively. Data are an average of 5 replicates per level. Within a species bars with similar letters are not significantly different ($P=0.05$, LSD).

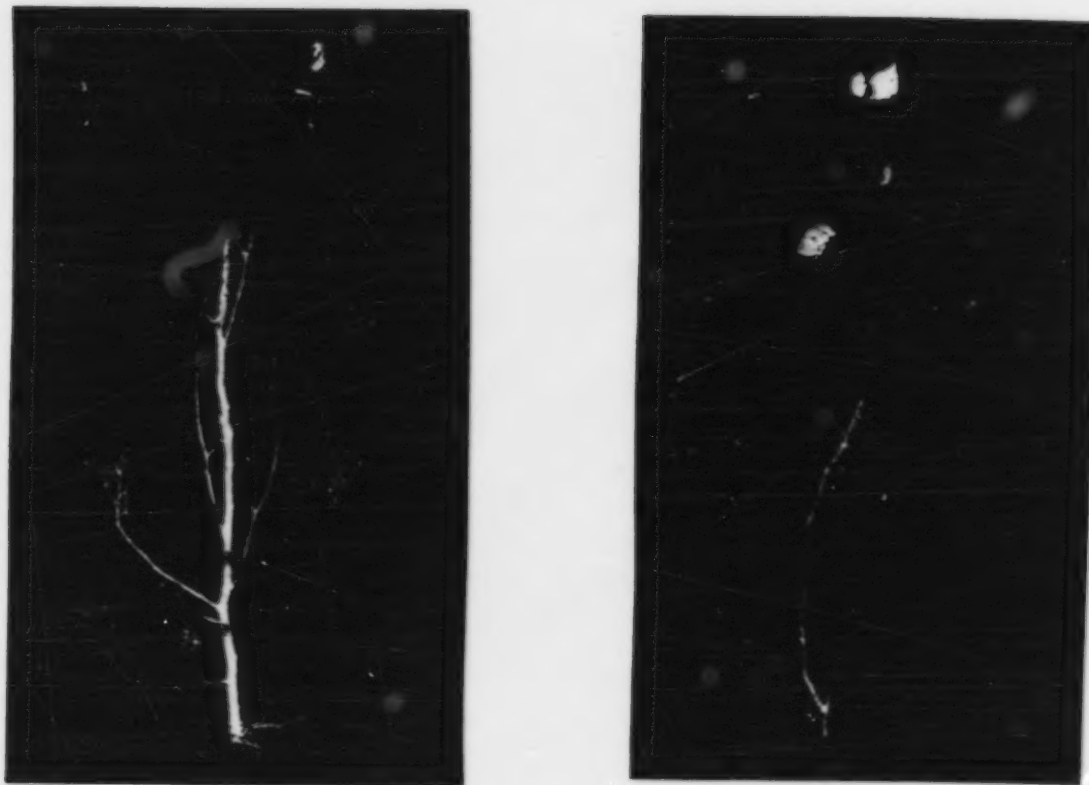


Figure 10/ Two poplar branches excavated from a brush layer, September 1989. At left is a four year old branch with partial rooting. At right is a one year old branch with very limited rooting. The arrow (15 cm long) at right indicates the origin of growth in 1988.



Figure 11/ Small willow live stakes, dug in September 1989,
with extensive rooting and several living shoots.

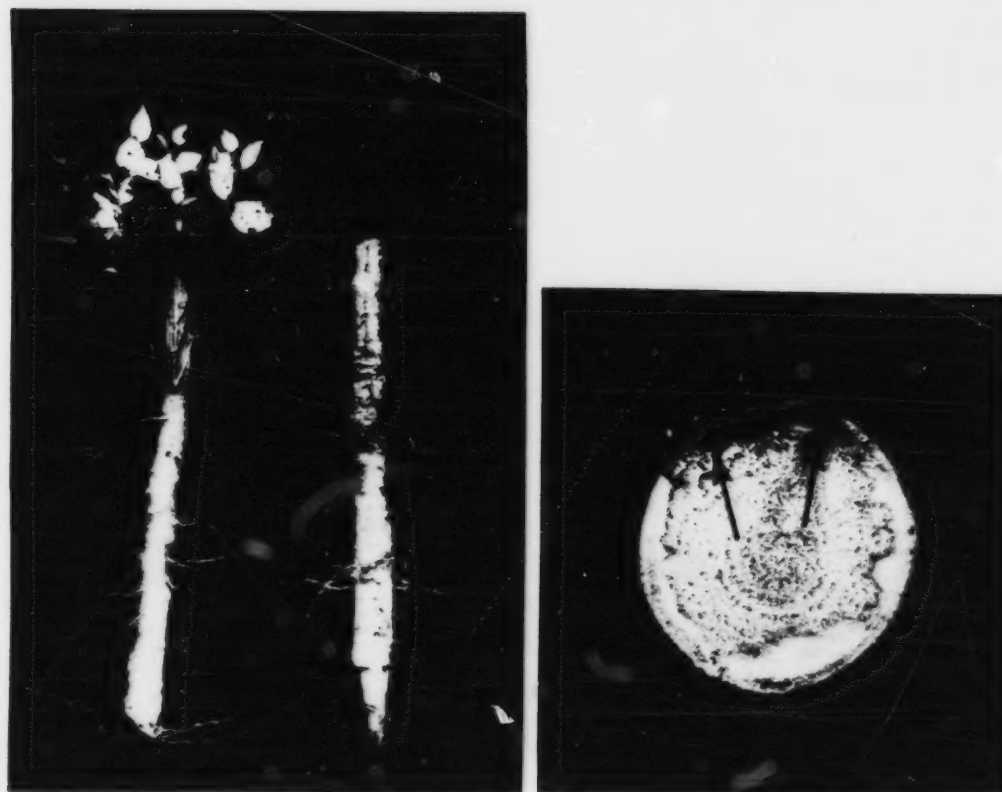


Figure 12/ Poplar live stakes, dug in September 1989, with limited rooting. The stake on the right died during 1989. The cross section reveals dead bark (arrows) on the side of the stake without roots.

Appendix 1: Soil Test, Pesticide Residue

RECEIVED JAN 27 1989



Ministry of Agriculture and Food
Ontario
AGRICULTURAL LABORATORY SERVICES
PESTICIDE RESIDUE SECTION
 Building #43, McGillivray St.
 University of Guelph
 Guelph, Ontario N1G 2W1
 Tel: (519) 823-8800 ext. 4825

Report No. 90- 4
 Agency ILM

Soil for Phenox's

Sender	E. Cavanagh Wentworth Plaza Wentworth, Ontario L3Y 2H1	Owner	Harrington & Hogle Ltd., 13 Harrington St., Wentworth, Ontario L3Y 2H2	Copy
Lab. No.	Sample Description	Content in sample as received (ug/g)		
9	soil 1	dieldrin	phenox herbicides	ND

Background site	Recommendation ID " not detected	Date received 08/12/30
		Date reported 89/01/17
		Analyst <i>K.I. Stonefield</i> K.I. Stonefield

Appendix 2: Forest Insect and Disease Survey

FOREST INSECT & DISEASE SURVEY-SAMPLING FORM

I. INSECT 2. DISEASE
NEAREST POST OFFICE

COLLECTION POINT (be specific)

Lookout Trail

Whitney

LOCALITY (use Forest Dist. or Div. or Drainage Div. or Political Sub-Div. or FIDS Dist.)

Laconquin D. Sprout T

510

UTM/GRID DESIGNATION

1770505

PLOT OR SAMPLE AREA NO.

12

ELEVATION

14

LOCATION

STAND EXAMINED

TREES SAMPLED

DATA ON INSECT(S) OR DISEASE(S)

GENERAL

1. Nursery	1. Undisturbed	1. North	1. Seedling (nursery)
2. Ornamentals	2. Clear cut	2. Northeast	2. Transplant (nursery)
3. Plantation (Nat. Sp.)	3. Selective cut	3. East	3. Seedling (forest)
4. Plantation (Exot. Sp.)	4. Burned	4. Southeast	4. Sapling
5. Shelterbelt	5. Insect damaged	5. South	5. Young growth
6. Hedgerow	6. Disease damaged	6. Southwest	6. Semi-mature
7. Woodlot	7. Animal damaged	7. West	7. Mature
8. Natural forest	8. Climate damaged	8. Northwest	8. Over-mature
9. Treed swamp	9. Wind damaged	9. Flat	
10. Scattered individuals	10. Water damaged		
	11. Agriculture		

2. BASAL AREA (Circle code of nearest no. of sq. ft.)

1. (165)	2. (46)	3. (99)	4. (132)
5. (198)	6. (254)	7. (287)	8. (320)
9. (353)	10. (386)		

3. FOREST SECT. 105 COVER OR SUB-TYPE 9900 DOMINANT SPECIES 1

4. HEIGHT OF DOMINANT TREES (Circle code of nearest ht. in ft.)

1. (7)	2. (15)	3. (30)	4. (45)	5. (70)	6. (100)	7. (140)	8. (180)	9. (210)
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5. TREE SPECIES W NO. OF TREES SAMPLED 99

1. Living	6. Rec. dead fallen	1. Dominant	4. Suppressed	7. Fringe
2. Rec. dead stndg.	7. Old dead stndg.	2. Codominant	5. Undergrowth regen.	8. Open
3. Rec. dead cut	8. Old dead fallen	3. Intermediate	6. Understory tree	9. Old vet.
	9. Manufactured			

1. Beating	2. Quantitative	1. Negative	1. Flower	7. Branch
2. Hand picked	3. Traps	2. Trace	2. Fruit	8. Stem
3. Ground observation	4. Aerial observation	3. Low	3. Buds	9. Butt
4. Photography	5. High	4. Moderate	4. Old foliage	0. Root
	6. N.A.	5. High	5. New foliage	0. Duff or soil
			6. New shoot	0. N.A.

SAMPLE UNIT NO. NUMBER OF UNITS 00 DAMAGE & HAZARD INDEX

COUNT PER UNIT AV. COUNT 000

FIDS NO. (See codes on cover) 79066 LAND OWNERSHIP (See codes on cover) 0 DAY 10 MO. 06

COLLECTOR B Smith

ADDRESS

REMARKS & SYMPTOMS

What killed it and when? \$65 000 spent on experimental plantings to stabilize soil along the highway. Trees were killed and buried except for those in the other area. Sample patch in the

Appendix 3: Well Water Analysis, Chemicals

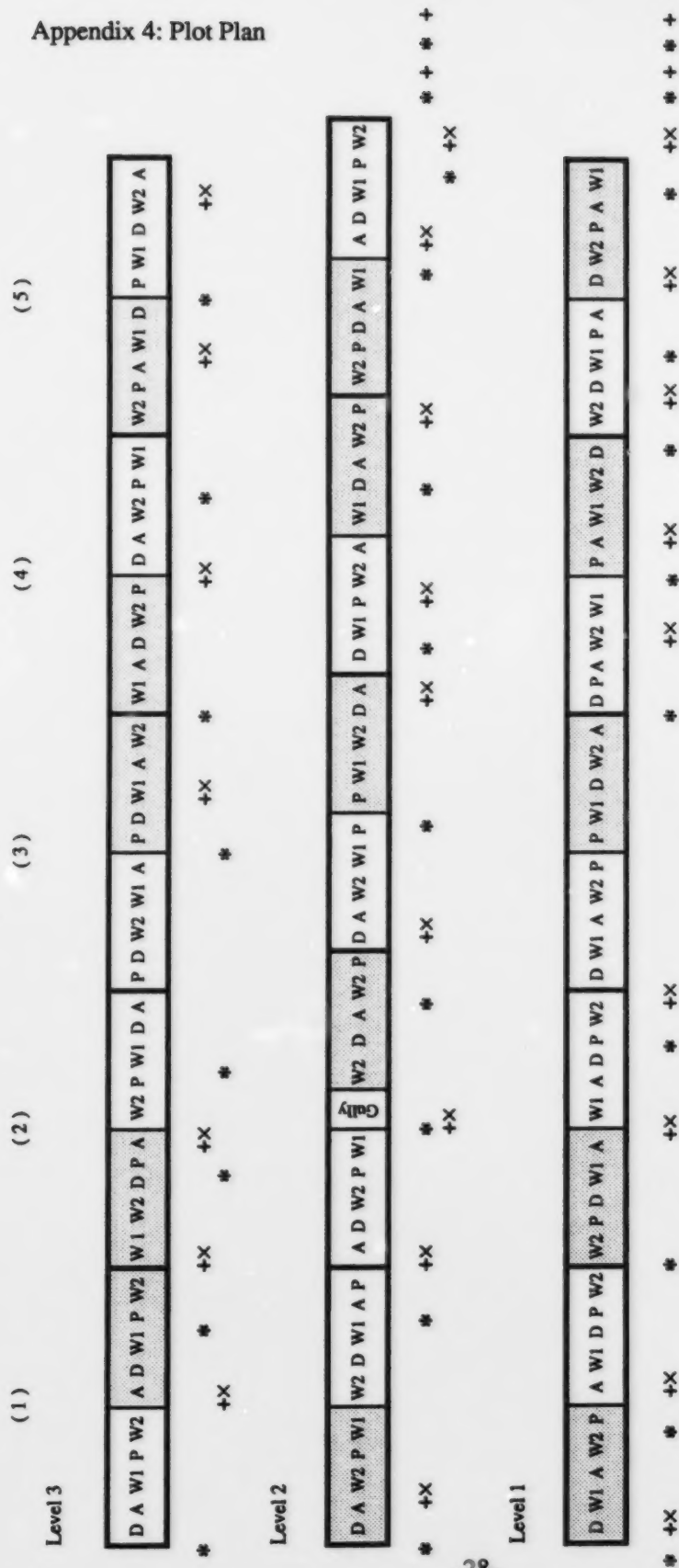
WELL WATER ANALYSIS ENGINEERING MATERIALS OFFICE CHEMICALS SECTION

SAMPLING Algonquin Park
LOCATION: District #11, Huntsville

TOUR FILE NO:
DATE: 88 05 25
OUR FILE NO: 3162-2-2-314

SAMPLING DATE	88 04 14	88 04 14	88 04 14	
SAMPLE IDENTIFICATION	#1 lowest level	#2 middle level	#3 upper level	
LAB. NUMBER	88-11219	88-11220	88-11221	
pH	7.08	7.65	8.27	
TOTAL HARDNESS (ppm CaCO ₃)	10	33	10	
ALKALINITY (ppm CaCO ₃)	5	25	5	
CHLORIDE (ppm Cl')	9	14	9	
SULPHATE (ppm SO ₄ ")	8	21	14	
IRON (ppm Fe)	0.2	1.5	0.2	
CALCIUM (ppm Ca)	2	11	2	
MAGNESIUM (ppm Mg)	1	1	1	
SODIUM (ppm Na)	1	3	1	
NITRATE (ppm N)	< 2	< 2	< 2	
CONDUCTIVITY AT 25°C (umho/cm)				
APPEARANCE	Slight Yellow Turbidity muddy	Yellow Turbidity muddy	Slight Yellow Turbidity muddy	
MANGANESE (ppm Mn)				
TOTAL: SOLIDS				
TANNIN				
TOTAL DISSOLVED SOLIDS (ppm)				

Appendix 4: Plot Plan



Legend

Live Stakes

- * Poplar
- + Large Willow
- x Small Willow

Brush Layers

- D Dogwood
- A Aspen
- P Poplar
- W1 Old Willow
- W2 Young Willow

- (1)
- Level 1
 - Level 2
 - Level 3

- No Fertilizer
- Fertilizer

